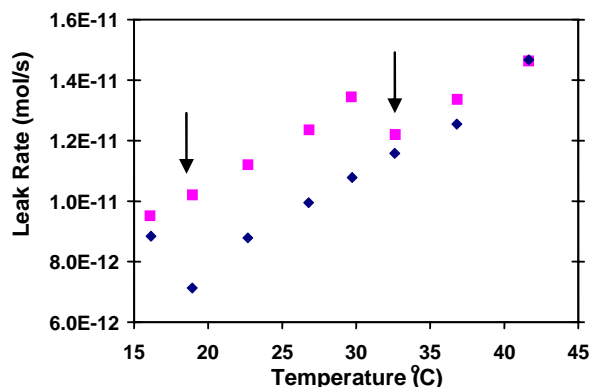


Metrological Shortcomings of Teflon-Based Helium Permeation Leak Artifacts

The Leak Calibration Program at NIST calibrates helium permeation leak artifacts for customers who use the artifacts to calibrate mass spectrometer-based leak detectors used for a range of leak qualification applications. Common applications include the testing of process chambers that operate under vacuum conditions such as in the semiconductor and space simulation industries. In many cases, quantifying leak rates provides a “go/no-go” indicator of overall process health. In order to ensure consistent and accurate measurements, it is vital that leak testing equipment be calibrated with accurate transfer standards.

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Leak artifacts consist of a containment vessel that is easily connected to the system of interest, generally using commonly used fittings. Recently it was discovered that certain types of helium leak artifacts that use Teflon™ as the leak element may have errors larger than their calibration uncertainties due to a temperature-induced phase change (Quinn Jr., Fred A., Roberts, Donald E., and Work, R. N., Journal of Applied Physics 22, 1085-1086, 1951) within the Teflon. The figure below shows discontinuities near 19 °C and 30 °C in the calibration of such a device that amount to a 30 % change, which is nearly four times the manufacturer’s stated uncertainty! In contrast, the behavior of a glass element helium permeation leak deviates by no more than a percent or two from a smooth exponential response with temperature.



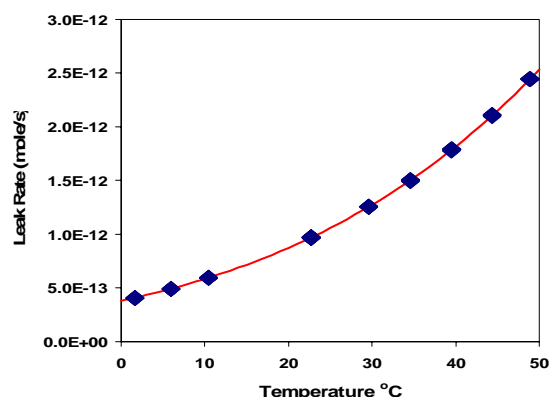
Calibration of Leak Rate vs. Temperature for a typical Teflon-element helium permeation leak. The diamonds indicate ascending temperature, the squares indicate descending temperature. Note the discontinuities (arrows) at 19° and 30°



Photo of a Teflon-element permeation leak artifact. The Teflon element is the white rod on the far right of the photo.

Accurate and non-destructive leak testing of sealed vessels is important in diverse industries, ranging from food packaging to nuclear waste containment.

Not all of the Teflon-based leaks tested at NIST showed the same extent of anomalous behavior with temperature, but alerting customers of the possibility of these types of errors should help in making the choice of a calibration artifact for a particular process uncertainty budget. Publication of these results is planned for an archival metrology journal (*Measure*).



Calibration of Leak Rate vs. Temperature for a typical glass-element helium permeation leak.